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I am not a number: Towards participatory IoT monitoring in the workplace

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Abstract

A dominant narrative around the Internet of Things (IoT) asserts that value will be realized by using resources more efficiently and by creating a better ‘user experience’. On the basis of a small qualitative study of reactions by employees to having their workplace monitored by networked sensors, we offer three guidelines to help ensure that smart office IoT initiatives incorporate a broader set of values and beneficiaries. We suggest that environmental monitoring in the workplace can create more value for ‘users’ and reduce the risk of adverse reactions if employees are more actively involved in the design and communication process.

1 Introduction

Early narratives of the Internet of Things (IoT) envisioned a ‘smart planet’ where interconnected things communicate with each other through a global information infrastructure, leading to efficient and seamless operations and generating virtually unlimited opportunities to develop new products and services based on insights from the data collected and analysed [1, 2]. Much of the interest in IoT has focussed on the notion of a ‘smart environment’, which in turn can be broken down into various application domains, such as smart home, smart office, smart retail, smart city, smart agriculture/forest, smart water and smart transport [3]. The vision of the smart city has generated considerable discussion and as noted by [4],

the smart city is currently being constructed as the solution to many urban problems, including crime, traffic congestion, inefficient services and economic stagnation, promising prosperity and healthy lifestyles for all. In short, the smart city symbolises a new kind of technology-led urban utopia...

However, this vision has attracted an increasing amount of criticism, particularly on the grounds that the agenda has primarily been set by the interests of global business [4], and that it takes a

top-down perspective with smart technology as a starting point, rather than starting from “ordinary urban places, knowledges and needs” [5]. More generally, there is a relative lack of research on the social, organisational, political and cultural implications of IoT and the need to recognise people as ‘integral parts of the systems’ in the Internet of Things [6]. The counter-narrative of ‘smart citizens’ argues that ordinary people should be at the centre of smart urbanism: “citizens can, and should, play a leading role in conceiving, designing, building, maintaining our cities of the future” [7, 8]. Digital technologies, including low-cost sensing devices, make it possible for citizens themselves to help co-create smart urbanism by directly participating in the IoT ecosystem [9].

The shift in the smart city concept and its use of IoT toward a more human-centred approach [2] has been reflected in the rise of social innovation and in a stronger social focus in urban research. This is linked to the rise of living labs, which “aim ... to involve citizens in innovation development as a new element of the decision-making process by connecting research with the actual living environment. Living labs serve as an instrument to test and improve new technologies, using potential future users to help shape and create new products and services that are both successful and competitive.” [10] The living lab approach advocates working with users to integrate their perspectives; involving them in co-design of systems, products and services; and ensuring that the smart environment incorporates their intelligence and reflects their changing needs, interests, values and experiences in a dynamic process of experimentation and innovation [11].

As an environment, the office shares characteristics with both the city and the home. Motivations for creating a ‘smart office’ have tended to share the values which are generally ascribed to IoT deployments, such as improving operations, optimizing assets, enhancing services, and providing security [12, 13, 3]. However, unlike the case of smart urbanism, there seems to have been little critical debate about developing a person-centred vision of IoT in the office — there is no narrative of ‘smart office workers’. In this paper, we describe a small study of reactions by university office staff to a pilot deployment of networked sensors for measuring occupancy and environmental conditions in an office block. We see our work as fitting within a living lab methodology that attempts to build on multi-stakeholder participation in real-life environments and places users on centre-stage [14].

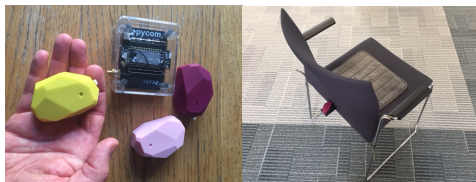
2 Office Monitoring Project

As part of a broad plan for estates management by the University of Edinburgh, several hundred staff from an operational services department, previously scattered across multiple sites, were rehoused in 2016/17 in open-plan offices within refurbished shared commercial premises. To complement the open-plan spaces, the ground floor of the premises was completely remodelled to contain an assortment of large and small meeting rooms.

In a separate initiative that had been building momentum throughout 2016, the University of Edinburgh established an Internet of Things network based on LoRaWAN, a secure long-range and low-power radio communications technology using the unlicensed spectrum for message broadcast by small battery-powered sensor devices. It was decided to help test the network by carrying out a pilot project to collect information about occupancy of the meeting rooms and environmental conditions in the office spaces more generally. This information was intended to help address two questions of concern to the University's building managers: (i) was the configuration of meeting spaces appropriate for the needs of occupants, and (ii) were the environmental conditions, particularly in terms of heating and ventilation, satisfactory in the open plan offices?

Environment & Occupancy Sensing

Please note that within this room, sensors have been deployed to enable monitoring of both the environment (temperature and light levels) and level of occupancy (door and chair cushion based sensors). The type of sensors deployed are shown below:



Please do not remove or unplug the sensors.

Please also note that no personal identifiers or personal identifying characteristics are being collected. The sensors used are not designed to identify who is in the room, only to determine the number of people present.

Further information about this project and the broader IoT initiative can be found at: <http://iot.ed.ac.uk/>
A full Privacy Impact Assessment has been carried out. If you have any concerns or other feedback regarding this project, please contact the project manager: XXXXX

Figure 1: The information poster that was placed prominently on the wall of the meeting room where sensors had been installed.

The pilot project deployed multiple devices that were networked using a combination of Bluetooth and LoRaWAN protocols. First, in one of the small meeting rooms, Estimote beacons with auxiliary sensors were attached to chairs.¹ An additional device containing an accelerometer and light-level

¹In addition to using the Estimote beacon's inbuilt accelerometer, its external GPIO pin was connected to a force-sensitive resistor in the cushion. This combination allowed us to measure whether the chair was moved and whether it

sensor was placed on the door, thus capturing when the door was moved and whether the light was on in the room. Second, sensors for light level, temperature, atmospheric pressure and relative humidity were placed near desks across one wing of an open-plan area.

Before installing the sensors, we carried out a Privacy Impact Assessment (PIA) in which we were careful to demonstrate that no personal data would be captured by the sensors.² Information about the pilot was communicated in two ways: by sending an initial email announcement to all building users, and by attaching a notice explaining the project to the wall of the monitored meeting room. Figure 1 illustrates the poster, which includes illustrations of the Estimote beacons used as sensors.

As we discuss in Section 5, subsequent investigation cast into doubt whether these communication steps were adequate in providing building users with an appropriate level of insight into the monitoring work.

3 The University as Living Lab

The office monitoring project aligned well with one of the strategic objectives of the University of Edinburgh's IoT Initiative, namely using IoT technologies to improve internal service delivery and operations. A second component of the strategy proposes using the city — and by extension, the University campus — as a Living Lab for IoT proof-of-concept experiments [16]. We interpret this to mean that a comprehensive approach to deploying IoT technologies must take into account the human dimension of those deployments [2]. People whose lives are impacted by IoT applications should have input into how those applications are designed, used and acted upon. Meeting room occupancy had been identified as an issue that affected most of the occupants in the office block that we studied, and therefore seemed to be an appropriate topic for exploring user engagement with living lab methods.

The office monitoring project was regarded as a pilot for developing a wider range of IoT-based interventions across the campus, and these would inevitably involve the student population to a greater or lesser degree. And as just indicated, the University's initiative envisages deploying IoT applications more broadly across the city as a whole. Consequently, we felt it was important to anticipate possible adverse reactions from people of all walks of life and to design our projects to preclude or minimise those.

In order to identify principles of design to support social acceptance, our user study started with the following goals: (i) identifying points of concern with the existing monitoring project; (ii) exploring whether the issues being monitored were really

was occupied within each two minute timeframe. The beacons were configured to transmit data over Bluetooth at least once a second. The data packets were collected by a Pycom LoPy sensor hub, which sent a summary message over LoRaWAN to a central server every two minutes.

²PIAs are becoming a critical part of the engagement process as part of new data protection legislation such as the General Data Protection Regulation [15].

the most important building concerns for users; and (iii) understanding user perceptions of the opportunities and pitfalls of monitoring. We also hoped to gauge the feasibility of engaging users from the outset in monitoring projects such as the one described in Section 2. Could adoption of a co-design process improve awareness and acceptability? In principle, this should happen as a result of office users being directly involved in the monitoring design, by creating a general perception that the project had key user input, and by ensuring that knowledge and understanding of the project was not limited to management but was shared across staff members who would in turn share information with their colleagues.

Besides increasing awareness and acceptability, it is likely that user participation in the design process would lead to new ideas for IoT applications that addressed users' perceived problems (which were not necessarily the same as those of the building managers) and potentially lead to more innovative or creative approaches to deploying IoT for the purpose of improving staff experience in the workplace.

4 Methods

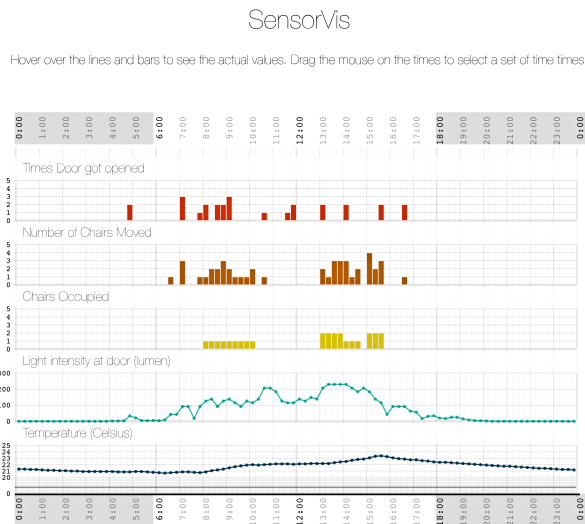


Figure 2: Screen dump of interactive data visualisation for a specific day. The x axis shows the time dimension at 15 minute intervals over the course of the day. Horizontal bands show values for: number of times the door was opened; the number of chairs that were moved; the number of chairs that were occupied; the light intensity in the room in lumens; and the temperature of the room in degrees Celsius.

4.1 Study Design

The main purpose of the study was to understand people's qualitative perceptions of monitoring in the workplace. We used semi-structured interviews and focus groups to explore indi-

vidual perspectives, organised around three main questions:

1. What do you know about the monitoring project and do you have any concerns about it?
2. What do you think are the main problems with the building and what would make your working environment better?
3. How do you view monitoring more broadly? What do you think about the use of data in various scenarios of building and office management?

We adapted the interviews slightly from our original plan to include a simple data visualisation, illustrating a sample day's data from the meeting room and demonstrating what categories of data were being collected; cf. figure 2.³ We invited participants to reflect on the data visualisation and to comment on what it revealed about human activities in the meeting room. We also asked what they thought would be the impact of making the monitoring data public through data visualisation: would it affect staff perceptions of the monitoring and would it increase their interest in engaging with the project?

4.2 Participant Recruitment and Data Analysis

Our candidate pool of study participants consisted of staff based in the offices where the monitoring project was carried out. An email from a senior manager was sent to all staff inviting them to participate. A separate email was sent to managers in divisions to highlight the study and ask them to encourage their staff to engage. Due to low initial response, additional reminders were sent out.

We recruited nine interview participants and a total of six participants for focus groups. One of the focus groups consisted of two participants and the other of four, based on staff schedules and availability. Some of the interviewees had heard of the monitoring project and one had seen it come through a security review, but none of them were directly involved with it.

Three interview participants were female and six were male. Four focus group participants were female and two were male. We did not ask people's ages, but a general estimate is that most participants were between 30 and 50 years of age.

We made audio recordings of the interviews, and used the transcriptions and hand-written notes to analyse the data based on emerging themes.

5 Results

Notation I1, I2,... refer to individual interview participants while (FG1, P1), (FG1, P2), (FG2, P1) etc. refer to focus groups participants.

³An online version of the visualization can be found at <http://www.aviz.fr/~bbach/occupancy/>.

5.1 Initial Reactions and Privacy Concerns

One of the first questions we asked was what participants knew about the monitoring project. Although they had all received the email that was sent out to all staff in the building, their level of awareness of the project depended on various factors. Some had not checked their email and were surprised to find the sensors in the meeting rooms and in their office space. Others knew more about the project because they sat next to people who were working on it, or they were involved in some aspect of the project themselves, or they had a personal interest in the University IoT programme and were following its activities.

A number of people were surprised when they discovered the sensors on the meeting room chairs,⁴ and found them rather curious, referring to them as ‘pebbles’ and ‘little guys’ (I2), ‘strange-coloured objects’ (I2), ‘pink Stealth bomber’ (I3), ‘pink lump’, ‘lump of flesh’ (FG2, P2), and a ‘little pink bug’ (FG2, P4).

In general, most participants seemed to understand that occupancy monitoring of the meeting room was not collecting personal data.

“I think the Internet of Things and the occupancy monitoring is fine, because actually it’s very anonymous. It’s not being who’s in and out or who’s part of the meeting or not – it’s just about is it [the meeting room] being used or is it not being used. It was quite clearly explained.” (I1).

“I don’t think they are spying on us. It’s fairly anonymous.” (I2)

“The whole monitoring thing, I have no problem with it, because it’s all confidential, and it’s all anonymous.” (I4)

“I thought it was quite exciting. I’m quite interested in technology and how technology can be used to deliver services more easily, to make work life easier, essentially to make things simpler. I think I was much more on the enthusiastic positive side of it rather than being negative.” (I5)

“No [concerns] absolutely not. Not worried at all.” (I9)

There were more negative reactions to the monitoring devices that were incorporated into the chair cushions, referred to as ‘bums on seats measurers’ (FG2, P4), which people felt were fairly intrusive.

“I was surprised when I got down to the room that they were on the seat part of the chair and you had to physically sit on them. That makes me uncomfortable.” (FG2, P1)

“It’s just too much in your personal space if it’s in physical contact with your rear end.” (FG2, P1)

“It was a bit strange... I wasn’t expecting to sit on something, that did feel a bit weird. It looks like an incontinence pad, it looks like somebody’s going to have an accident.” (FG2, P2)

“I didn’t like sitting on it either but I probably would have felt a bit stupid to say I don’t really want to sit on that thing. It’s not

really any different from sitting on a chair... I don’t know, it’s... I feel... it doesn’t know it’s [my] bum...” (FG2, P3)

“The buttock sensors are a little bit intrusive. Sitting on a sensor seems a step too far.” (I6)

“It’s a little bit weird to sit down on the seat with the pad on it.” (FG1, P1)

Despite the email about the project and the information poster into the meeting room, some people had concerns about what the devices were doing and what information they were collecting.

“We were wondering at first what they were... these strange-coloured objects that were appearing everywhere. [We] guessed it would be something with monitoring the room occupancy, that they would be different types of sensors...” (I3)

“You have to wonder, what data is it gathering, because it could be gathering much more data than just a simple binary, is someone sitting here or not? Body temperature and everything else could be gathered potentially... that just feels too intrusive.” (I6)

“There’s lots of discussion about whether it’s measuring how warm you are, whether you’re wiggling, whether you’re wriggling... I don’t know that we necessarily know exactly what it’s monitoring. Is it monitoring whether I’m asleep? Is it monitoring the level of anger and frustration in the room by the wiggling and wriggling and fidgeting?” (FG1, P1)

“... you see that thing and you think, oh, is that recording what we’re saying?” (FG2, P1)

“All I saw was pink things being stuck up... there was a lot of speculation about what they were.” (I9)

5.2 Data as Evidence

As conversation progressed toward more of the details of the project and the issues that people experience in the building, there were more positive reactions about the potential of the project to deal with an identified issue. Almost everyone interviewed had experienced some frustration with the meeting room situation in the building.

“It will be quite interesting to see what did we learn about how we use space or do we actually occupy it when we say we’re meant to. Often I’ll walk by and these big rooms will be empty... a lot of this can help with the data in terms of what do we actually use.” (I3)

“I think it’s a great idea. It can be quite frustrating when you’ve got 2 people in a room of 10. Smaller rooms seem to be in demand a lot more for 1-to-1s, half an hour slots, that kind of thing.... The [breakout spaces] are not confidential, they’re not private enough for particular types of conversation, and the noise carries.” (I4)

⁴Cf. the devices illustrated in figure 1.

“Even though there will be times in the day when some of the meeting rooms will be empty, it’s difficult to get a room basically for a meeting at less than a fortnight’s notice.” (FG2, P1)

“I’m often booking small meetings in big meeting rooms down here because you do occasionally need the big rooms, but what we need is more rooms.” (FG2, P3)

“The occupancy is really useful... because you can see, are these large meeting rooms actually being used full all the time or are they only getting 1 or 2 people.” (I5)

As mentioned in Section 4, we used a simple data visualisation to show people what data was being collected. The visualisation allowed people to understand better exactly what data was being collected and to offer their own interpretation of it. It also opened up opportunities for them to suggest other ways that the data could be used to address pertinent building issues.

One thing that multiple people noticed and questioned was the data collected on chair movement. Collecting data on chairs occupied seemed to make sense in the context of occupancy monitoring, but it wasn’t clear what data on chair movement would contribute to the question. However, at least three people mentioned that the configuration of rooms was an important issue to consider.

“...If you could actually see how the chairs are being moved so you see whether they get put into a theatre style so many times or whether they get moved into circles.” (I5)

“Actually if you had the number of chairs moved in a high level of detail, you’d probably be able to see if someone had gone in and reorganized the room before everybody else arrives, which would show if they’re reconfiguring the space... timetabling worr[ies] about how much time people spend configuring space... how effective the meeting can be or how effective they teaching can be if you’re having to get everybody get all the chairs and then get them in a circle and put them all back before you can leave...” (I3)

One person thought that data from the door opening and closing could provide some interesting insights and motivation to people to arrive on time for meetings.

[looking at the data visualisation] *“Ah right ok, so that’s people coming in. Interesting that they don’t all arrive at the same time. Quite often in the University we are terrible for starting meetings on time... you’ll start a meeting and then someone will pop in 5, 10, 15 minutes into a meeting which can be quite disruptive.” (I3)*

A number of people mentioned the value of ‘evidence-based decision-making’ rather than ‘guessing’ (FG1, P1).

“We’re always trying to look for evidence and we don’t always have quantifiable data that we can use.” (I3)

“More data should lead us to better decisions as opposed to management by ‘I think and I feel’” (I6).

5.3 Potential for IoT on Campus

There were multiple other building issues apart from meeting rooms that people mentioned. Noise seemed to be a key one that was also in part linked to the issue of meeting rooms and not having sufficient spaces to use outside of the open plan office areas — either for private conversations or for louder group meetings.

“Are you going to do noise sensors in the offices upstairs by any chance? When you’ve got these breakout areas, the noise rises and then comes down, and it might help inform what you can do with the information you’re collecting.” (I4)

“I think it would be quite good to monitor noise levels as well. This space is a little bit tight... on my floor. It might be better to have everyone who needs quiet space in one area and everyone who needs noisy space in another area. There’s just too much noise, and it’s quite disturbing at times.” (I5)

Asking for people’s input and engaging them with the data being collected in the project opened up a wider conversation around other ways that data could be used. It seemed to draw out the people who had experience in using data to design services and improve user experience, business analytics and intelligence and environmental monitoring, among other things.

“I’m quite interested in generally understanding how students use the University overall... and why they use particular spaces within the library over other spaces... I’m also interested in... how do you have an equitable experience digitally as well as physically and what does that mean in terms of what you need to provide for students? ... I’m always interested in results and what we can do to make things better.” (I1)

“... to be able to look up some kind of app, to go, that desk is free, that would be ideal for a lot of people who hot desk. That would be something that I think a lot of people would appreciate and benefit from.” (I4)

“I would find that quite useful if you could look at the trends of what sicknesses are in different areas or if there was any kind of correlation between temperature and density of staff against absence levels... if you were tracking me... you would see that in Student Systems I was off a lot, so that would indicate there was something possibly wrong with the room or the job.” (I3)

“[data from sensors] can help us to test some assumptions that we’ve had in the past as well about what we expect users to be like. Even if the data simply confirms something that is probably quite obvious, it is useful nonetheless to have data to prove that. ... further investment [in] the library needs to be evidence-based, and so if we can provide and triangulate data from these other sources, I think it would give the University more confidence that what we’re doing is a) needed and b) going to realise the value to the students.” (I7)

5.4 Surveillance and Management

While people were for the most part comfortable with the existing scope of the monitoring project, they had concerns about expanding it within the workplace, particularly if it touched on them personally. We asked them what they would think about various scenarios of being personally monitored, from having a monitor on their desks to having their movement and around the building and physical activity tracked.

Responses were mixed, with some people being particularly curious about what could be learned from additional monitoring but most having some concern about how the data would be used and what the implications would be.

“If it [a monitor on my desk] were trying to establish whether me and another colleague could share a desk... that might be fine, and I’m quite up for that, but it would be about the communication back to me as an individual... whether it’s monitoring me, specifically, at that particular point in time, then I might feel quite different about it.” (I1)

“People maybe worry about what the consequences are — if you start monitoring someone’s usage of their own desk — would we opt for hot desking, because actually we can cram 150 staff into space for 100 because nobody’s actually ever at their desk all the time.” (I3)

“Seems to be three dimensions to it. One is, if you try to identify the fact that the person’s based at a certain place, or the sex of an individual, or the age of an individual — once you start going down that road, that’s one dimension. The next is — will one thing lead to another? So once you give assent for this, will you suddenly find yourself being monitored — even anonymously — for other reasons and more reasons beyond that? ... So they say they’re going to monitor the way you use your PC for one reason — to improve efficiency — and then a year down the line, if they come back and say, well, we will use this data to work out that... there’s a lot of time you’re not working, or you’re not working on the right stuff, or you’re on your personal email too much... And also there’s no time bound — it seems to be, once it’s in place, it’s in place for good — and no one ever seems to say it comes to an end at some point... is the data going to be kept forever, and all that stuff, and can you use that data for other purposes than what they said?” (I2)

“If it was staff offices... I think colleagues would be very disconcerted by that and they would wonder what on earth it possibly was that was being monitored and why. We would need to be careful that... it wasn’t contributing to a culture of surveillance.” (FG1, P1)

One participant responded to the first questions about the monitoring: *“I must confess, it doesn’t bother me at all. We’re getting monitored every day, everything that we do — I’m quite used to that.”* But later, when she was asked how she would feel about having her desk monitored, she became a bit more sceptical: *“Okay, so that might be slightly different actually. I would question that I supposed. I probably would want to understand why. As long as I was told what it was for and that*

I was able to genuinely see the data that it was getting from that, then I probably would be alright. I might say definitely if it happens.” (FG1, P2)

There was a particular concern about the personalities and culture of management.

“I can see that I would be slightly nervous about it [if my desk was being monitored] in the beginning, I was like, hang on, I’m being watched, my boss could use that against me potentially... I know managers that would do that.” (I4)

“One of the places where I worked in the past we had an over-the-top clocking in system. Because there was a bad management culture there, it got misused. The problem there wasn’t so much that we had information. The problem was that there was a bad management culture. If your managers know that they want efficiency, and they want people to be motivated and productive, the way to do that is the human side — that you’ve got to encourage people to be efficient, have transparency about your budgets, let people feel valued, trust them.” (FG2, P1)

“We might end up in a situation where we’re saying, well only 97% of the screens are in use in public labs, so we don’t need to make any more space — the fact that the students are all crammed in like chickens, well it’s alright, because there are actually 3 desks in the library free. So monitoring is good but it depends what the management do with it.” (FG2, P3)

“Obviously as long as it’s anonymised we’re not very worried, but we’re aware of past cases where overzealous management has misused technology.” (FG2, P4)

“It could be abused... Heavy-handed management which can be done with or without technology would be very undesirable.” (I6)

5.5 Transparency and Purpose

While participants expressed their concerns about the expansion of monitoring and the collection of personal data, they also directly or indirectly suggested things to be done that could assuage their concerns. They wanted to know the reason for the monitoring and how the data was being used, and whether it would bring any benefit to them.

“[if my personal desk was being monitored] ... I think I’d want to know that it was happening, and I’d want to know why it was happening, and I would want to know how the data is being used and what use it’s going to be put to afterwards, and what the rationale behind it was.” (I1)

“If you’re going to gather data, only do it if it’s for a purpose and you’ve got a real objective.” (FG2, P1)

“As long as there’s a purpose... I think it really helps if you can see how the data is being used...like visualised in some way that is easy to understand and look at whenever you want. I’m okay with sharing some information... if there’s some personal benefit to me of providing that data, then I’m usually quite com-

fortable providing it, but otherwise if I don't know what they're going to do with my data then I won't." (FG1, P2)

"I think with a lot of these things it's just being confident that you know what you're signing up to, that you know what's going to happen to your data, and you know that if it's going to be used in any other way, that you're always asked permission... it's made totally clear to you so that you understand exactly how your data's going to be used. I think you have to be sort of transparent with this sort of stuff, and I think there probably is quite a lack of trust." (15)

"As long as you know the reasons why something's being collected, that's really important. As long as it's very clear what the proposed benefits might be as well as what other sorts of decisions might be made based on the data, then I don't think people have a problem. I certainly don't." (19)

They wanted the monitoring actions and the resultant decision-making processes to be communicated clearly, and they wanted to give people the option to participate in decision-making.

"The key is always being very open and transparent and really communicating as best you can. If they were looking into making particular decisions or changing certain things, it would be nice to say, we're doing x to this meeting room, do you agree or not agree. If there were a number of different options for a particular meeting room, you could see the information, see which the different options were, and vote, have input. For me one of the more important things is to say, we're putting up all this monitoring stuff... yes, it's actually going into decision making based on what we've found out. Otherwise why are we bothering to do this and spend lots of time on this if we then don't change things and don't act on the information?" (11)

"If people know when a decision is likely to be made and to see the outcome of participation, however small it might have been — then people will stay interested. If it's some nebulous affair where a decision will be made 'at some point' — people won't believe in it." (12)

"You want to be efficient but you also want to be transparent, because all you're going to produce is data which people can use and statistics. And statistics can be interpreted differently — there always needs to be a context behind statistics." (FG2, P3)

"It's about who has your data and what they're doing with it. Awareness can lead to a very different reaction to what you'd expect. People hemorrhage data constantly, but once they start thinking about it, you suddenly find they develop this very risk-averse behaviour on the back of it. One of the big things about collecting data — you need to create that level of informed consent. It's how you get people engaged and involved, and the minute it comes home and it's to do literally with them, and they feel it's much more personal, you'll get more out of people." (18)

They wanted to help others understand what monitoring is doing and what it achieves.

"We're not really trying to profile an individual, what we're

trying to do is see what impact this building has on people or has on a group of people, and I think when you explain that to people then it's usually not too bad." (13)

"...it's getting away from that perception of it being a judgment — because that's quite often what people will think, that when you put numbers against something they see it as being a judgment and actually numbers are just trying to show what happens and a reflection of the activity that goes on, and you can get insight from that that isn't necessarily about it being good or bad — it's just what actually goes on." (13)

"I do think actually just informing people of the information that's being gathered and the options to help improve things... I think a lot of the time you just have to show people the benefit, rather than just say oh, we're collecting this. A lot of people don't understand why." (14)

6 Discussion

6.1 Perceptions of monitoring

Among the many different and mixed responses to the idea of IoT monitoring in the workplace, most people seemed to fall more or less into one of the following categories:

1. *I'm not so bothered* (FG1, P2), (14) — I'm already being monitored in so many ways that are so much more personal e.g., CCTV in the building, mobile phone apps, etc.
2. *Data can help* (11, 13, 15, 16) — There are so many ways that we could use data like this to improve our workplace experience and the work that we do. We can create a lot of value and benefit if we use this technology well.
3. *Show me the change* (12), FG2, P3) — Is all this monitoring really necessary? Can I see what data you're collecting? Will the data actually be used to inform a change? How will I know if it is? Might there be easier or simpler ways to achieve the necessary change?

The first category represents someone who already willingly shared a lot of personal data or was completely aware of how much personal data was already being collected from him/her with or without transparency and well-informed consent e.g., through various apps. The second category reflected a person with previous experience of using sensors or data analytics in their work. They were not likely to react negatively to the monitoring and were keen to contribute ideas and suggestions about more monitoring options and how they could be used to improve user experience and services generally. The third response was found to some degree in many of the conversations but was particularly pronounced in a few cases, which represented people with the most potential to view IoT initiatives skeptically or negatively.

6.2 Challenges

The responses of our study participants indicate that there are number of challenges to be addressed in engaging with users when deploying IoT applications in offices and other places of work.

One of the most striking features of the participants' responses was the extent to which they felt underinformed about the nature and goals of the office monitoring project. Although the initial measures that we took (email, information poster) in communicating with staff about the project 'ticked the box' in terms of standard approaches to data protection compliance, it fell short in engaging their attention and interest to properly understand the what, how and why of the data collection.

Privacy was not originally a primary concern of our study. Nevertheless, reflections on privacy and surveillance surfaced frequently in the comments of the study participants.

We can frame some of these concerns in terms of *information spaces* [17] in the sense of "a way to organize information, resources, and services around important privacy-relevant context factors.... A *boundary*—physical, social, or activity-based—delimits an information space." In the monitoring experiment, physical boundaries were clearly important in determining information-spaces. We chose to monitor a meeting room specifically because it was a common space, not linked to any specific individuals, and therefore less likely to trigger privacy concerns. Conversely, the desks that people occupied in the open plan offices defined much more personal information spaces, albeit not demarcated by such clearcut physical boundaries. It is clear from comments in Section 5 that many participants saw monitoring of their desks as a source of concern. While this was not being considered as an extension of the meeting room monitoring, many people viewed an initial monitoring project as a potential 'foot in the door' to expand and extend monitoring activities.

The chairs in the monitored meeting room were somewhat less easy to classify in this scheme. Again, they can be regarded as information spaces, given that sensors were attached to them. And although they are only transiently associated with any one individual (i.e., for the duration of a meeting), the study results show that several participants were sensitive about the physical closeness of the sensors. [18] proposes to characterise a breach of privacy as the state which arises when one of 'my' boundaries are crossed, and if I feel that 'my chair' or 'my-body-on-the-chair' is being monitored, this can be perceived as intrusive.

O'Hara's [18] approach to privacy involves seven 'levels', of which the first level is occupied by the *underlying concept of privacy* — provisionally identified in terms of whether a significant boundary has been crossed. The second privacy level concerns the *empirical facts* of the matter. The monitoring project took steps to ensure that no personal data was collected by the sensors; in particular, the chair sensors were configured in such a way that they only allow binary discrimination, namely

was a 'sitting' event detected at a given measuring period or not.

O'Hara's third level is characterised in terms of *phenomenology*: regardless of the empirical facts of privacy, how is the situation perceived by the subject. In the case of, say, a social media platform, I may feel that I am having a private conversation with a friend, unaware that in fact a lot of information is being collected by the company that owns the platform. However, if the presence of IoT monitoring devices are explicitly signalled to a user, and indeed have a visible form factor, then the converse perception of being surveilled may easily arise, even if the perception is ill-founded.

In terms of deploying an IoT monitoring system, we are therefore confronted by the problem of a potential discrepancy between privacy level two and level three: we are not collecting personal data, but the physical devices being used may prompt concerns from people that the opposite is true. Ideally, we would like to be able to make demonstrably evident that the data flow from sensor to processing system carries no personal information, for example by a suitably configured visualisation in one of the office's public spaces. This is essentially the notion of *computational accountability* discussed in [19]: "the surfacing or making visible of computational behaviours or actions to better enable human-computer interactions. However, in our case, we are particularly interested in the ramifications of accountability in the group setting of an office, rather than in terms of individuals as data subjects.

As pointed out in Section 1, most discussions of IoT systems focus on technology stacks and engineering concerns [20, 12], with human actors being relegated to the margins [6]. Considering the 'massive and pervasive' impact and implications of IoT, careful and thorough consideration and integration of the end-user perspective and experience is necessary [21]. However, to begin considering the human adds a layer of complexity and difficulty and requires the system to become more flexible and adaptive to changing needs and interests as well as diverse applications [2]. While there were commonalities across study participants in terms of building issues that affected them, it would not have been possible to address each person's concerns. Concerns were also described in greater detail than ideas about how to solve them.

The use of design principles and practices in the context of living lab experiments can bring users to the forefront of the process and allow them to 'co-evolve' with the technology [2]. In this way they not only contribute to the development of the technology and its uses but also allow themselves to learn about the new opportunities that it offers and to develop their perspectives and ideas alongside it.

The issue at stake is not the social acceptability of IoT for the purpose of getting people to accept it and allowing a technocratic vision to advance unimpeded. Rather it is how to stimulate curiosity and 'educate' users about technology through active participation — in designing the system to meet their needs but also in becoming more consciously aware of its implica-

tions and making informed decisions about how much they let it shape their lives — and how much they will exert their own initiative to shape it.

6.3 Achieving acceptance

We propose three principles for promoting acceptability and trust. The potential of IoT to maximise resource efficiency and improve user experience is widely espoused and offers a seemingly easy ‘quick win’ application. However, the way in which IoT applications are designed and delivered is crucial to their acceptability and either limits or expands their potential to create shared value. These three guidelines can help to overcome skepticism and ensure that IoT monitoring projects incorporate a broader set of values and beneficiaries.

Transparency Anyone affected by the monitoring should be informed about what data is being collected and should be able to access an easily interpretable explanation of this, for example through data visualisation. Physical signage in monitored areas is more effective than email communication. If possible, some version of the raw data should be accessible to anyone interested in exploring it and comparing their interpretations to that of the decision-makers.

Purpose Monitoring should be a time-bounded activity with a clearly defined purpose. Individuals who might be affected by the monitoring should be informed about the what, why and how of decisions made based on the data collected. Overmonitoring by “well-meaning technophiles” should be avoided when simpler interventions could achieve the desired goal.

Participation In the case of workplace monitoring, there is an opportunity and a need to move beyond the narratives of resource efficiency, maximising productivity and incentivising specific behaviours. Trust in management decision-making has been compromised by the use of data to justify cost-cutting and provide only a minimum acceptable level of facilities and resources.

New narratives built around trust and valuing individuals can be created by involving employees in identifying the issues that most affect their performance, comfort, health and well-being and determining how and whether monitoring could be used to address these issues effectively. The engagement process can be structured to offer employees freedom, creativity, and a sense of agency.

7 Conclusion

We have described how staff space in a shared commercial meeting was monitored, focussing particularly on how occupancy levels in a small meeting room were determined using

a variety of connected sensors. The monitoring project served two goals, both to test the viability of an end-to-end IoT architecture, and to gather data that would be of interest to building managers. This allowed us to experiment with a cluster of issues that were affecting a significant group of people in their workplace, and to do so in a context where people would generally tend not to have adverse reactions but rather to be interested in the project.

The main focus of the work presented here investigates how staff reacted to having their workplace monitored in this way. We conducted a small qualitative study into how they responded to the use of connected sensors in their environment and what lessons we could carry forward to improve the design of future projects along such lines. Based on our analysis of the results of the investigation, we proposed three guidelines for achieving user acceptance of IoT workplace deployments, divided into the categories of transparency, purpose and participation.

We have also argued that projects of this kind could unlock much more value by going beyond questions such as “How can I make this acceptable to staff?” or “How can I involve users?” By encouraging users to participate as key stakeholders in the co-design of IoT experiments, project owners can gain access to pathways, opportunities and ideas that they would be unlikely to discover by themselves. At the same time, it can empower people to innovate and discover new possibilities for using IoT for social benefit.

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